CHAPTER 2 – REVIEW OF LITERATURE

This chapter looks at the conceptual and empirical background for the present study. The initial part of the chapter gives an overview of mental health in children, with specific reference to learning and children at risk for learning problems. The second part of the chapter deals with principles used in designing intervention programmes. The third section examines studies using computers for intervention, especially in children with problems in scholastic performance. The various sections are as under:

2.1 Mental Health in children
2.2 Children at Risk
2.3 Cognitive functions and learning difficulties
2.4 Studies from India

2.5 Difficulties in identifying children at risk
   2.5.1 Referral
   2.5.2 Temperament
   2.5.3 Teacher ratings

2.6 Indian studies on prevalence of scholastic difficulties

2.7 Intervention
   2.7.1 Cognitive Interventions
   2.7.2 Learning and transfer of learning
   2.7.3 Assessing effects of training
   2.7.4 Technology in training and intervention
   2.7.5 Effects of cognitive interventions in children
   2.7.6 Computer-based intervention for academic difficulties
   2.7.7 Comparing different types of training
   2.7.8 FastForWord
   2.7.9 CogMed

2.8 The Brain Functions Therapy

2.9 Summary and appraisal of available work
2.1 MENTAL HEALTH IN CHILDREN: Mental Health problems in children have been a challenge to clinicians and policy makers alike. The chapter in Mental Health- Services and Barriers to Implementation of the WHO 2000 report of the Ministerial Round Table has specified children and adolescents as a special group, with the following observations:

1. In most countries of the world, development of psychiatric services for children has lagged behind those of adults.

2. With the spread of universal education, schools are becoming the most appropriate venue for health related interventions in children.

In most countries, children are considered a vulnerable group with special mental health needs (WHO report 2001). Mental health, which includes emotional and behavioral areas of health, is a critical component of child well-being. It may impact children's physical health, relationships, and learning. Data from the National Health Interview Survey show that in 2005-2006, 15% of U.S. children aged 4-17 years had parents who talked to a health care provider or school staff about their child's emotional or behavioural difficulties(Simpson, Cohen, Pastor& Reuben, 2008).

There is a large overlap in a variety of childhood psychiatric disorders (Pataki, 2005). This high degree of co-occurrence of behavior problems in children makes it difficult to diagnose a single, “pure” condition (Elia,Ambrosini & Berrettini, 2008). The co-occurrence of disparate symptoms and syndromes also raises questions about the etiology and mutual inter-dependence of various disorders. Children with one developmental problem are also at considerable risk of having one other problem. Co-morbidity or co-occurrence is the rule, not the exception in Child Psychiatry (Kaplan, Dewey, Crawford &Wilson, 2001).

2.2 CHILDREN AT RISK: There is a broad repertoire of cognitive and behaviour problems that bring children to clinical attention for learning difficulties in diverse learning environments. This repertoire often includes deficits in discrete academic skills, however, it is rarely restricted to these (Aloyzy-Zera, 2001).
School related problems were found to play an important role in help-seeking behavior (Zwaanswijk, Verhaak, Bensing, Ende, van der, Verhulst, 2003). Learning at school is a complex process for some children (Semrud-Clikeman, 2006). Some of the basic functions required at school include speaking, reading, writing, and the ability to solve mathematical problems. For about 10% of all school children this may be hard work (Srinath, Girimaji, Gururaj, Sheshadri, Subbakrishna, Bhola, & Kumar, 2005; Hackett, Hackett, Bakta & Gowers, 1999). It is even harder work for their teachers and parents, to understand the child’s different needs and respond appropriately.

Academic demands on the child continue to increase throughout schooling (Gresham, Macmillan & Bocian, 1997). Research on reading difficulties in children has typically focused on early emerging difficulties that are identified prior to fourth grade (Leach, Scarborough & Rescorla, 2003) i.e. when a child “learns to read”. In higher grades, the child has to “read to learn”, where heavier demands are made, not just for deeper understanding of the text, but also for dealing with the more challenging aspects of the more basic processes, leading to the “year four slump”. This group which emerges after fourth grade with difficulties in reading, is a heterogeneous group with one group showing deficits in comprehension, another with deficits in word processing and a third showing having difficulties in both areas (Leach, Scarborough & Rescorla, 2003; Galletly, Knight, Dekkers & Galletly, 2009).

For children with learning difficulties, coping with the academic curriculum can be very difficult. The longer a child with learning difficulties continues without assistance in the upper primary grades, the more pervasive their deficits are likely to be (Wooley & Hay, 2003).

Failure to diagnose learning problems can have adverse educational and psychological consequences for the child and family. A mild difficulty unattended to in the early years, could lead not just to severe learning problems later on, but also to secondary emotional and behavioral problems.
2.3 COGNITIVE FUNCTIONS AND LEARNING DIFFICULTIES: A difficulty in learning can result when cognitive functions do not develop normally at the appropriate stages of childhood. Mental retardation, autism and attention deficit hyperactivity disorder and reading disorders are all examples of conditions where learning has gone wrong. The cognitive profiles in such conditions cast little doubt that many children with difficulties in learning have underlying neurological deficits (Gilger & Kaplan, 2001). Information processing, attention and working memory are 3 areas that have been researched in the area of learning difficulties at school.

**Information processing** weaknesses may well be the primary basis of the child’s problems in successfully adapting to the child’s environment (Morgan, Singer-Harris, Bernstein, Waber, 2000; Singer-Harris, Forbes, Weiler, Bellinger, & Waber, 2001). Information load, slower processing and difficulties in complex processing have been associated with inadequate academic performance.

**Attention** is a core function that has separable networks computing different functions (Posner & Rothbart, 2005). One of these is the executive attention network that involves the anterior cingulate gyrus and lateral pre-frontal areas, which are strongly activated in situations that call for attentional control. Deficits in attention can be inborn, as seen in children with ADHD and have been often shown to underlie poor performance at school (John, George, Rajiv & Kurien, 2006; Karande, Satam, Kulkarni, Sholapurwala, Chitre & Shah, 2007).

**Working memory** is a function that has been of interest to researchers in the field of learning disability. Deficits in working memory have strong correlation with a child’s academic performance (Gathercole & Pickering, 2000). Complex memory span scores are strongly related to teacher’s ratings of the child’s general abilities at 4 years of age. (Alloway,Gathercole,Adams&Willis, 2005). They can also effectively predict scholastic achievement over the subsequent school years (Gathercole, Brown & Pickering, 2003). Working memory plays a crucial role in supporting learning, with poor progress in reading and mathematics characterizing children with low memory skills (Holmes, Gathercole & Dunning, 2009).
Failure to adapt to the environment has been used in the contextually referenced model of Luria and Vygotsky,( Kaplan, Dewey, Crawford & Wilson, 2001; Aloyzy-Zera, 2001). The term “neuro-psychologically based learning disorder” refers to children who fail to successfully adapt to the school environment because of certain characteristics of their neuropsychological makeup (Morgan, Singer-Harris, Bernstein & Waber, 2000). These characteristics have the potential to disrupt the child’s performance in academic settings; however, they may be relatively invisible to traditional, standardized measures of achievement that focus on discrete academic skills.

2.4 INDIAN STUDIES: There are a few Indian studies that have explored the neuropsychological profiles of children with learning difficulties. Agarwal & Kar (2007) studied 17 children aged 8-13 years and diagnosed as dyslexic, using the NIMHANS neuropsychological battery for children. Multiple deficits emerged in the profiles obtained. The main areas affected were temporal, fronto-temporal, and temporo-parietal areas. Most children had deficits in visual learning.

A wider range of assessments were carried out by Krishna, Oomen & Rao (2007). They assessed 60 children in the 3rd to 7th grades, from English medium schools in Karnataka, who presented with learning difficulties for intelligence, neuropsychological functions and learning disability. Four types of learning disability were identified, while neuropsychological deficits were of 2 types- diffuse cortical deficits and fronto-temporal dysfunction. The type of deficit was influenced by the age of the child as well as the neuropsychological profile.

These findings are pointers to the heterogenous nature of learning difficulties. Children with such difficulties may present with varying profiles, not only in academic difficulties but also of assessed neuropsychological functions. This is even greater in multi-lingual countries such as India, where the learning at school can be in a language not spoken at home (English).

Thus there is growing clarity on link between the specific cognitive functions and difficulties in academics(Noble, Tottenham & Casey, 2005), but the specificity of
these deficits to children with learning problems and other functional outcomes of the deficits remain far from clear.

2.5 DIFFICULTIES IN IDENTIFYING CHILDREN AT RISK: Despite a growing body of research, the ability to accurately identify which young children are at risk of developing reading disabilities remains elusive (Ritchey & Speece, 2004). Some of the issues facing early identification efforts include the type of measures used for screening, timing, definition of classification accuracy, and the criteria for "at risk" and "reading disabled" status. Assessment of learning difficulty remains a highly visible, controversial and important facet of school activities. Establishing acceptable criteria for the identification of learning difficulties has been the single most controversial issue in the field of Learning Disability.

The discrepancy between ability and achievement has been a common way of identifying learning disability. This approach is based on two features- intellectual ability and academic achievement, both of which need to be assessed using standardised tools, followed by a comparison of the standard scores. If the comparison shows that a student’s “achievement” is well below his “ability” in reading, writing or arithmetic, then, a diagnosis of learning disability may be made. This approach however, has poor reliability and validity and tends to over-identify those with high IQ and average achievement, and under-identify those with low IQ below-average academic achievement (Semrud-Clikeman, 2006).

The discrepancy model has often been criticised for the Mathew effect (Stanovich, 1986). Students who are strong readers are in a better position than poor readers to expand their vocabulary, increase their fund of general information, improve their comprehension and thus, learn more about the world (Dombrowski, Kamphaus & Reynolds, 2004). Difficulties in reading may lead to poorer scores on intelligence tests; however, the discrepancy between ability and achievement may not be very high. Such children would therefore, not be identified as having learning problems, especially in the early classes.
Students’ achievements do not begin to fall off until tasks at school or on the achievement test becomes increasingly abstract and cognitively more demanding. It has thus been criticised as the “wait and fail” model (Mather & Roberts, 1994) that does not provide early intervention at the right stage, but waits for the child’s performance to decline substantially before intervention is provided.

Scholastic difficulties in children may be the result of several factors, physical, psychological, environmental, developmental (John, George, Rajiv & Kurien, 2006). A learning difficulty may be indicated when students demonstrate **unevenness** in their development of skills, in particular, achievement profiles, However, the absence of unevenness does not mean that the student does not have difficulties in learning.(Vaughn & Fuchs, 2003). Normal range achievement test scores among children do not necessarily indicate absence of neuro-developmental vulnerability.

2.5.1 **REFERRAL** for psycho-educational or psychological assessment itself can be regarded as a potential indicator of dysfunction. (Waber, Weiler, Forbes, Bernsteing, Bellinger, & Rappaport, 2003, Singer-Harris, Forbes, Weiler, Bellinger, & Waber, 2001, Morgan, Singer-Harris, Bernstein, & Waber, 2000). They compared 65 children aged between 7 and 11 years with normal scores in academic achievement with low achieving children matched for age, sex, and non-verbal cognitive ability and also to children with no known history of learning difficulty, on a battery of computerized tasks of non-verbal information processing. Roughly half the children referred, presented with a complaint of **inattention**. The authors believe that children who are easily overwhelmed by online processing demands, can appear inattentive and hence acquire a diagnosis, partly because, no other canonized diagnosis is available. Normally achieving children performed worse than their non-referred counterparts, but similar to the low-achieving group. Both groups showed poor performance on measures that are sensitive to efficiency and ability to manage complexity. The authors believe that they have vulnerability to increase in processing load in tasks involving non-verbal stimuli. Their profiles were similar to but less severe than that of peers with dyslexia, suggesting a similar underlying biological substrate in both referred groups (Morgan, Singer-Harris,
Bernstein & Waber, 2000). The results from this group of researchers, suggest that **children can perform adequately on standardized achievement measures and yet struggle at school;** these children can possibly have heightened neuro-developmental vulnerability.

The authors speculate that these two groups of referred children may represent different points along a continuum of severity with greater severity resulting in frank dyslexia. This pattern may also reflect the co-existence of multiple layers of problems; vulnerability to load may exacerbate the already weakened function of the neural circuitry that affects reading (Singer-Harris, Forbes, Weiler, Bellinger, & Waber, 2001).

**2.5.2 TEMPERAMENT** is an important aspect of the child’s behaviour. Each child has a specific temperamental pattern of response, which can be discerned throughout the child’s lifespan. Traits that coincide with child’s developmental tasks frequently determine how they are perceived. A temperamentally verbal child often appears “bright”, while a less verbal child is frequently underestimated in cognitive maturity. As childhood progresses, traits that determine success at school are predominant. A child who is temperamentally deliberate and goal directed, functions well in a traditional school setting. An impulsive, non goal-directed child may be mislabeled as having an attention problem or characterized as unmotivated (Gordon, 2005).

Difficult child temperament, limited cognitive abilities, low self-esteem, poor peer relations, school difficulties are some of the risk factors associated with childhood (Cole, Cole & Lightfoot, 2005). Protective factors include high self-esteem, positive peer relations, positive adaptation to school and good mental health. They have looked at child characteristics in the microsystem, exosystem and macrosystem.

**2.5.3 TEACHER RATINGS** can be significant predictors of school outcome (Gresham, Macmillan and Bocian, 1997). In their study, the authors found that teacher ratings of how much a child was learning, as compared to peers, were the most useful predictor of later academic problems. Nearly all children who were
rated average or below average developed academic difficulties later; whereas children rated above average did not. This is consistent with the finding that there are a large number of children who have average achievement and learning difficulty. These are the children who are often missed as they are not identified by achievement levels alone. (Taylor, Anselmore, Foreman, Schatschneider, Angelopoulos, 2000).

Children with problems in learning are hence, a heterogenous group, who experience real challenges at school, in the home. (Noble & Bowd, 2005). This is especially true of a multi-lingual country such as India, where the child has to learn multiple languages at a very young age. Apart from the language spoken at home, there are at least two other languages the child has to learn at school. At the macro level, there is little uniformity between the governing bodies that supervise education in different states. Children in India, are therefore, high at risk for problems in learning, likely to be under-identified and therefore, not referred for help.

2.6 INDIAN STUDIES ON PREVALENCE OF SCHOLASTIC DIFFICULTIES: There is limited data on child mental needs in our country (Srinath, Girimaji, Gururaj, Sheshadri, Subbakrishna, Bholo, & Kumar, 2005), even less for children with learning and behaviour problems (Hirisave & Shanti, 2002). In an epidemiological study in urban and rural areas of Bangalore, in the 4-16 year age group Srinath, Girimaji, Gururaj, Sheshadri, Subbakrishna, Bholo & Kumar (2005) reported a prevalence rate of 12% for child and adolescent psychiatric problems. Academic difficulties were reported in approximately 10% of the group.

Scholastic problems were found in 9.4% of children, in a school based epidemiological study from North India (Malhotra, Kohli & Arun, 2002). In a rural area of Kerala, a rate of 9.4% has also been reported in the age group 8-12 years (Hackett, Hackett, Bakta & Gowers, 1999).

In a study of schoolchildren from an urban area of India, 36% of children identified by teachers were found to have significant behaviour problems (Gupta, Verma,
Singh & Gupta, 2001). Within this group, scholastic underachievement was found to be associated with maximum problems. Teachers proved to be better informants for identifying children with academic difficulties but were almost unable to identify potential mental health problems on the questionnaire used (Srinath et al, 2005). Clinic based studies (Karande & Kulkarni 2005, Karande, Satam, Kulkarni, Sholapurwala, Chitre & Shah 2007, Karande, Kanchan & Kulkarni, 2008) have highlighted the need for early identification and intervention for children with learning problems.

**Children under 16 constitute over 40% of India’s population** and information about their mental health needs is a national imperative. Even if families do not perceive problems as causing significant functional impairment, they do have disturbing intra-psychic consequences. This cautions us against concluding that these children’s problems are likely to resolve without any mental health intervention (Srinath Girimaji, Gururaj, Sheshadri, Subbakrishna, Bhola, & Kumar, 2005). Early mental health screening and the availability and use of appropriate services would thus, be one of the primary goals of a mental health practitioner in India.

These findings suggest that approximately 10% of children have difficulties in scholastic performance, which is a huge population. Despite the lack of psychiatric diagnosis in most of them, this is a group whose needs have to be addressed. Scholastic problems may thus, be a good starting point for intervention in children.

**2.7 INTERVENTION:** The ability to learn, grow and develop is fundamental to human survival. Home and school are the two major environments that the growing child learns from. Children’s life experiences can influence their neuro-cognitive development and lead to anatomical and functional changes in their brains (Noble, Tottenham & Casey, 2005). Given the brain’s role in learning, it is natural that there is a link between education and neuroscience (Pickering & Howard-Jones, 2007). One of the issues in linking brain development to education is to find out whether classroom interventions can alter neural networks related to cognition, in ways that can generalize beyond what has been taught. The
ability to understand these processes could provide opportunities to convert experimental findings into improvements in education (Posner & Rothbart, 2005).

Identification of neuropsychological deficits and linking the assessment of processing deficits to effective interventions has been lacking (Kavale & Forness, 2000, Silver, 2001) especially in children with learning problems. Integrating knowledge of the neuro-developmental substrate in an ecologically relevant context should be an organizing principle in educational assessment and intervention. (Morgan, Singer-Harris, Bernstein&Waber,2000). Appropriate treatment and intervention for children with emotional or behavioral difficulties has been shown to lessen the impact of mental health problems on school achievement, and relationships with family members and peers (Simpson, Cohen, Pastor & Reuben, 2008)

2.7.1 COGNITIVE INTERVENTION: Cognitive remediation, retraining or intervention is terms that refer to systematic therapeutic efforts to improve cognitive functions (Cicerone, Dahlberg, Kalmar, Langenbahn, Malec, et al, 2000; Sohlberg & Mateer, 2001). Cognitive intervention studies on children, are few, based on small samples and often include no control conditions (Mateer, 1999). They are usually modified versions of training available for adults (Warchausky, Kewman, Kay, 1999; Gontkovsky, McDonald, Clark, & Ruwe, 2002; Hagberg-van’tHooft, 2005).

Cognitive functions may vary in how easily they can be improved through training. Cognitive training has promising effects, but there have been inconsistencies regarding the type of effects demonstrated by different training programmes. Two types of effects are possible. First, there are practice effects on the tasks included in the intervention programme (Klingberg, 2010; Buschkuehl &Jaeggi, 2010; Barnett & Ceci, 2002). Secondly, effects could generalize to related cognitive constructs (such as WM training having effects on inhibition) or behaviours related to the trained construct, i.e. cognitive training on school performance (Jaeggi, Buschkuehl, Jonides & Perrig, 2008).

Intervention programmes are, ultimately based on principles of learning. The next section looks at some of these principles and their application in the design and
implementation of intervention programmes.

2.7.2 LEARNING AND TRANSFER OF LEARNING: Learning and plasticity are fundamental properties of the nervous system. The type of experiences that favour learning and brain plasticity is of significance to research. Various aspects of intervention have been studied including factors related to the tasks, factors within the learner and other extraneous variables.

Kilgard & Merzenich (1998) showed that when specific auditory tones are paired with stimulation of certain parts of the brain, the area of the primary auditory cortex that represents the given tone increases dramatically. Brain systems thought to convey the utility of reward (ventral tegmental area, nucleus basalis) play a significant role in producing plastic changes in sensory areas(Bao, Chan & Merzenich, 2001) Roughly the same amount of dopamine is released in the basal ganglia while playing an action video game, as when methamphetamines are injected intravenously (Koepp, Gunn, Lawrence, Cunningham, Dagher, Jones et al, 1998), implying that stimulation takes place when a person is actively engaged in a task.

Video games have been used to demonstrate the enhanced perceptual and cognitive skills in the players (Green and Bavelier, 2006, Bavelier, Green, & Dye, 2008, Cohen, Hodson, O’Hare, Boyle, Durrani, McCartney et al, 2007; Achtman, Green, & Bavelier, 2008, Trick, Jaspers-Fayer & Sethi, 2005), following training. However, there was little generalization of the expertise gained to other environments (Sims and Mayer, 2002, Destefano and Gray, 2007). Significant training-induced changes in motor functions too, have been documented in a number of studies (Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995; Pascal-Leone, Nguyen, Cohen, Brasil-Neto, Cammarota, Hallett, et al 1995).

Task difficulty controls the rate and type of learning (Ahissar & Hochstein, 2004). Harder tasks are at a disadvantage when it comes to promoting learning transfer. Learning progressed quickly and transferred to novel orientations when tasks were easier, than when they were difficult (Ahissar & Hochstein, 1997)
The importance of using **optimum increments** in learning new tasks (Linkenhoker & Knudsen, 2002) along with feedback and reinforcement have also been emphasized (Dayan, 2001).

Specificity of improved performance to the task trained, has been demonstrated in the field of perceptual learning (Saffell & Mathews, 2003, Fahle 2004) and in motor functions (Redding, Rosetti & Wallace, 2005; Redding & Wallace, 2006). Learning can be general and flexible, if it occurs at the level of richly structured representations that contribute to a wide array of behaviours, than when it targets neural networks that govern highly specialized functions. Ahissar and Hochstein (2004) believe that learning occurs at the highest level of representation that is sufficient for the given task. Easy tasks allow for a sizeable learning transfer because they may be learned at a high level of representation that may be shared with other tasks.

**Variability** (of context and items) is another issue that affects flexibility of learning. This ensures that subjects ignore specifics of the object and learn to extract more general principles (Brady & Kersten, 2003). High variability is crucial in ensuring that the level of representation of newly learned informative fragments is that which can flexibly recombine (Reeler, Newport & Aslin, 2008).

Minimizing the “surprise” element in learning is important (Courville, Daw, & Touretzky, 2006) as also, **active involvement**. Action provides learners an opportunity to evaluate their internal representations and fine-tune them if a discrepancy is noted between the actual and predicted outcome (Sutton & Barto, 1998).

Thus, the factors to be considered in planning a training regimen are several. For those designing rehabilitative or educational programmes, the challenge lies in overcoming the key obstacles that prevent the programmes from reaching their full potential. Simple, predictable tasks that are gradually made more challenging might be effective in children. Factors extrinsic to the actual intervention such as reinforcement and maintenance of motivation are other variables that also need to be kept in mind.
2.7.3 ASSESSING EFFECTS OF TRAINING: The evaluation of training depends significantly on the choice of outcome measures. Outcome measures that are closely related to the training experience are more likely to show improvements (Busckehuhl & Jaeggi, 2010).

The effect of training may sometimes be illusionary. Transient effects lasting a few minutes may at times, be causally attributed to training. However, they cannot be consistently replicated; for example, the effect of music on a spatial reasoning task (Fudin & Lembiss, 2004; McCutcheon, 2000). In reality the source of the effect may be a short-term arousal or mood changes. The effect of training should therefore be measured at least a full day after completion of training, in order to ensure robustness of learning.

Other variables that need to be looked into include comparison with a control group and persistence of effects. The ecological validity of the results should also be proved—interventions that succeed in the laboratory must be tested in real classroom environments before they can be widely implemented.

2.7.4 TECHNOLOGY AND LEARNING: Technology may appear sterile, unnatural or foreign, but the reality is that with decreasing cost and increased availability, they have invaded mainstream life. This increased availability and use provides a potential avenue for dissemination of evidence-based prevention and treatment interventions (Taylor, Webster-Stratton, Feil, Broadbent, Widdop, Severson, 2008). The computer is one such device that has become increasingly used for personal, professional and now, therapeutic use.

Computer-based programmes allow control over stimulus presentation; they allow repeated learning trials in an identical or systematically varied format. Feedback or computer-based reinforcers can be delivered immediately following responses. The delivery of responses can also be varied to reduce satiation or changed for schedule spacing purposes (Gontovsky, McDonald, Clark & Ruwe, 2002)

2.7.5 COMPUTER-BASED COGNITIVE INTERVENTIONS IN CHILDREN: There are several studies on computer-based interventions for
children with difficulties in learning. Autism is one of the clinical conditions, where such interventions have been attempted.

Computer-based interventions have been used in children with autism to teach specific skills such as enhance vocal imitations (Bernard-Opitz, Sriram & Sapuan, 1999), improve vocabulary (Bosseler & Massaro, 2003) and enhance problem-solving (Bernard-Opitz, Sriram, Nakhoda-Sapuan, 2001). Williams, Wright, Callaghan & Coughnan (2002) found better gains in learning and less resistance to being taught, when material was presented in computers than with instructors. Moore & Calvert (2000) found that while the rate of learning has been similar in both methods, use of computers have increased motivation and attention and reduced inappropriate behaviour in these children.

2.7.6 COMPUTER-BASED INTERVENTION FOR ACADEMIC DIFFICULTIES: Focusing on specific cognitive functions and using combinations of functions that have been proved effective, appears to be the approach used in most studies involving children with academic difficulties. The available work can be broadly classified into programmes targeting language, attention and working memory, either individually or in combination.

Math fact retrieval deficit often occurs concurrently with reading difficulty (Geary, Hamsen & Hoard, 2000), phonological deficits are often noted in both word reading and arithmetic fact retrieval (Fuchs, Fuchs, Hamlet, Powell, Capizzi, & Seethaler, 2006). Fuchs et al studied the potential of computer-assisted instructions to enhance number combination skill in a group of first graders with concurrent risk for math and reading disability. Acquisition and transfer effects were studied after students were randomly assigned to the math or spelling group and completed 50 sessions over 18 weeks. The results were moderately significant, with limited transfer being noticed to other math or reading skills.

Shalev, Yehoshua, & Mevorach (2007) studied the effects of attentional training (30-60 min, twice a week for 8 weeks) on a group of school going children and reported no effects of training on mathematics. Significant effects were however noticed on passage copying and reading comprehension.
A study of attention training for typically developing pre-schoolers showed that short-term attention training led to improvements in behavioural and neural measures of attention that also generalized to measures of non-verbal intelligence (Reuda, Rothbart, McCandliss, Saccomanno & Posner, 2005). A community sample of four year olds who attended 5 sessions of attention training showed significant improvement on abstract reasoning skills, as compared to a group of controls who watched videos. Their brain activity too was more adult-like than that of the control group on a cognitive control task administered after their training was complete. This suggests that training that targets attention explicitly might be an efficient means of improving not only attention but also generalised intelligence and learning in domain-specific contexts.

Adolescents with dyslexia showed greater gains following a 10 week writing intervention if they first received 10 weeks of attention skills training as opposed to 10 weeks of reading fluency training (Chenault, Thomson, Abbott & Berninger, 2006). Thus, prior training in attention might help children with language deficits benefit more from targeted instruction in an academic domain.

There have been several studies on reading and intervention related brain plasticity (McCandliss & Wolmetz, 2004). Children with mild to severe reading impairment have benefitted from interventions that focus on phonological awareness and alphabet decoding skills (Torgesen, Alexander, Wagner, Rashotte, Voeller, & Conway, 2001; Vellutino Scanlon, Sipay, Small, Pratt, Chen, et al, 1996).

Temple, Deutsch, Poldrack, Miller, Tallal, Merzenich & Gabrielli (2003) studied the effect of behavioral remediation on a group of 20 children, aged between 8-12 years with dyslexia. Improvement was reported in oral language and reading performance; the activation pattern on the fMRI too showed a greater activation in multiple areas, closer to the pattern seen in normal children. No control group was used. Shaywitz, Shaywitz, Blachman, Pugh, Fulbright, Skudlarski, et al (2004) reported improvements in the performance of children individually tutored in phonological skills, as compared to a group that received school based remedial reading instruction.
Rigorous use of control groups would add validity to the interpretation of behavioral efficacy and neural specificity of intervention effects. Studies have typically included as controls, non-impaired children who were not given the intervention. Inclusion of a similarly impaired control group would help determine whether changes following intervention were specific to the intervention, or whether other factors could have influenced these changes—generic tutoring, schooling, task novelty.

2.7.7 COMPARING DIFFERENT TYPES OF TRAINING: This section focuses on 2 computer-based interventions that have been systematically studied in recent years—the Fast ForWord (FFW), focusing on language and Cogmed, focusing on working memory.

2.7.8 Studies using the FAST FORWARD PROGRAMME: The FFW programme is based on the theory that language deficits arise from more basic perceptual deficits in processing.

Pokorni, Worthington, Jamison, (2004) and Cohen, Hodson, O’Hare, Boyle, Durrani, McCartney et al (2005) used a randomised controlled trial design to study the efficacy of FFW in children with language impairments. Their findings did not suggest any additional benefit of this particular software over other methods of intervention.

A neuroimaging study (Temple, Deutsch, Poldrack, Miller, Tallal, Merzenich & Gabrielli, 2003) provided preliminary support for the hypothesis that FFW may influence attentional systems. Following training, there was increased activation observed in the anterior cingulated (Bush, Luu & Posner, 2000) which could indicate changes in attentional skills. This indicates that the neural mechanisms of selective auditory attention can be remediated through training and can accompany improvements on standardised measures of language.

The anterior cingulate has been associated with attentional control, especially when task demands produce response conflict, for example during the Stroop test (Botvinick, Cohen & Carter, 2004).
This study reported increased activation of the anterior cingulate during a pseudo-word reading task in readers with dyslexia following FFW training. The authors speculate that the increased anterior cingulate activation might be related to changes in aspects of attentional processing. No behaviour measures of attention were included in the study. These data add to the growing body of evidence indicating considerable variability and modifiability in the neural mechanisms of selective attention. Enhancements in the effects of attention on sensorineural processing have been observed among individuals congenitally deaf (Bavelier, Tomann, Hutton, Mitchell, Corina, Liu, & Neville, 2000) or blind (Roder, Teder-Salejarvi, Sterr, Rosler, Hillyard, & Neville, 1999). The data suggests that training programs can be effective at normalising the brain systems responsible for the earliest effects of selective attention on sensorineural processing.

One longitudinal follow up of children with dyslexia for 2 years after the end of FFW training reported that the standard scores on the language assessment regressed back towards pre-intervention levels by the end of the second year (Hook, Macaruso & Jones, 2001). Another study reported that some, but not all standardised test gains following FFW training had remitted 3 months after the intervention (Loeb, Stoke & Fey, 2001). These findings indicate that language gains might not be maintained over time.

Gillam, Loeb, Hoffman, Bohman, Champlin, Thibodeau et al (2008) tried to overcome the limitations of these studies (small sample, inclusion of children with specific impairments) in their approach. The study examined whether 6 weeks of intensive computerised training (100 minutes a day) designed to improve language skills would also influence neural mechanisms of selective auditory attention. Over a 3 year period, 216 children between the ages of 6 and 9 years with language impairments were randomly assigned to 4 programmes, 3 of which were computer-based- the FFW-L, academic enrichment, computer-assisted language intervention and an individualised intervention by a speech-language pathologist. The children were trained for 5 days a week for 6 weeks, for 1 hour and 40 minutes each day.

Frequency and duration of intervention was held constant, while they compared 3 critical dimensions of intervention: computer-delivered versus human-delivered
services, and specific versus non-specific intervention goals. Three post-training assessments were done immediately after, 3 months after treatment and 6 months after treatment, by an assessor blind to the study. The children were tested before (within 30 days of initiating the training) and after (within 30 days of completion of the program) the training; the no-treatment control group were tested and retested at a comparable period. On an average, there was a period of 85 days between the pre and post testing. The children also completed standardised language assessments and event-related brain potential (ERP) measures of selective auditory attention. A token economy system was implemented to maintain motivation.

The children who received training showed increases in standardised measures of receptive language. They also showed larger increases in the effects of attention on neural processing following training relative to the no-treatment control group. The effect size was large (Cohen’s d = 0.8). The children in all 4 interventions made similar amounts of improvement and these improvements continued for the next 6 months. The findings revealed that the FFW-L was not more effective at improving general language skills or temporal processing skills than the 3 other methods. The authors concluded that a variety of intervention activities can facilitate development in children.

2.7.9 THE COGMED PROGRAMME: This programme involves computer-based training on a variety of working memory tasks for a period of 20-25 days. The programme has been used on both adults (Westerberg, Jacobaeus, Hirvikoski, Clevberger, Ostensson, Bartfai & Klingberg, 2007) as well as children (Klingberg, Fernell, Olesen, Johnson, Gustafsson, Dahlstrom, et al, 2005; Klingberg, Forssberg & Westerberg, 2002). Studies (Klinberg et al 2002; Kimberley, Eso & Thomson, 1999) have shown that young children with ADHD can benefit from training on tasks involving prefrontal function. In a multi-centre randomized controlled double-blind trial (Klingberg et al, 2002), 44 referred children aged 7-12 years, with ADHD but who were not on medication, were included. Training was for 20 sessions, participants were randomly assigned to either the computerized programme or a comparison programme. The outcome measures included tasks of working memory, general mental ability (colored progressive matrices) and rating
by parents and teachers. Apart from the post-intervention assessment, a follow up assessment was done 3 months later. Significant improvements were reported on the outcome measures, which persisted on follow up. The effect did not, however, generalize to other functions. The authors caution that short-term retraining may be required for the effects to be sustained.

In a study involving pre-schoolers, Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, (2009) used 2 types of computerized tasks in training- visuo-spatial working memory or inhibition. The children were trained for 15 minutes per session, for about 20 sessions. Computer games were used in an active control group, while a passive control group took part only in pre and post assessment Children trained on working memory tasks improved significantly, not only on trained tasks, but also on non-trained tasks of spatial and verbal working memory, as well as attention. The authors speculate that WM and inhibition tasks activated overlapping areas of the ventro-lateral prefrontal cortex, thus providing the neural basis for the transfer between WM and inhibition. WM training proved to be significantly effective on non-trained WM tasks (spatial and verbal) as well as on laboratory measures of attention. Neuro-imaging findings have shown evidence of supra-modal WM areas within the parietal and pre-frontal cortex(Curtis & D’Esposito, 2003, Hautzel, Mottaghy, Schmidt, Zemb, Shah, Muller-Gartner et al, 2002), where brain activity has been shown to increase as an effect of WM training(Olesen, Westerberg & Klingberg, 2004, Westerberg & Klingberg, 2007). Those trained on inhibition tasks, showed improvement in some of the trained tasks, but did not have generalized effects.

Holmes, Gathercole & Dunning (2009) used the programme on children with low working memory scores, to find out the effect of training on working memory and measures of academic ability, both immediately after as well as 6 months after training. Twenty two children aged about 10 years completed the adaptive version of the programme while a comparison group of 20 children completed a non-adaptive version of the programme. The difference between the 2 versions was the level of flexibility- in the adaptive version task difficulty could be adjusted to the child’s performance. In the non-adaptive version, the difficulty level was fixed
throughout the training period. Training was for 35 minutes a day, for at least 20 days. Working memory improved significantly in children who underwent the adaptive programme and the gains persisted on follow up. Generalisation was noticed to non-trained functions and also academic performance, though this was more significant on follow up rather than immediately after training. These effects were not noticed in children who underwent the non-adaptive version. IQ did not improve considerably with training. The authors speculate that while working memory and intelligence are related (Kane & Engle, 2002, Jaeggi, Buschkuel, Jonides, & Perrig, 2008), they contributed differently to academic difficulties (Cain, Oakhill & Bryant, 2004).

Summary of some of the studies involving computer-based intervention

<table>
<thead>
<tr>
<th>Author</th>
<th>Training</th>
<th>Sample</th>
<th>Age</th>
<th>Control</th>
<th>Transfer effects measured To WM</th>
<th>Other cognitive</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klingberg et al</td>
<td>CWM</td>
<td>ADHD</td>
<td>7-15 yrs</td>
<td>Active</td>
<td>Span board*</td>
<td>Stroop*</td>
<td>CPM*</td>
</tr>
<tr>
<td>Klingberg et al</td>
<td>CWM</td>
<td>ADHD</td>
<td>7-12 yrs</td>
<td>Active</td>
<td>Span board*</td>
<td>Stroop*</td>
<td>CPM*</td>
</tr>
<tr>
<td>Thorell et al</td>
<td>CWM, spatial</td>
<td>Healthy</td>
<td>4-5 yrs</td>
<td>Active</td>
<td>Word span*</td>
<td>CPT*, go-no go</td>
<td>Block design</td>
</tr>
<tr>
<td>Holmes et al</td>
<td>CWM</td>
<td>Low WM</td>
<td>8-11 yrs</td>
<td>Active</td>
<td>Complex span*, Instruction WM*</td>
<td>Mathematical reasoning*</td>
<td>WASI</td>
</tr>
<tr>
<td>Holmes et al</td>
<td>CWM</td>
<td>ADHD</td>
<td>8-11 yrs</td>
<td></td>
<td>Complex span*</td>
<td>WASI</td>
<td></td>
</tr>
</tbody>
</table>

CWM - computerised working memory task, ADHD- attention deficit hyperactivity disorder, WM- working memory, CPT- continuous performance task, CPM- Raven’s coloured progressive matrices, WASI- Weschler abbreviated scale of intelligence, * indicates significant effect on the task

Cognitive training can be divided into two types- implicit where repetition, feedback and gradual adjustment of tasks is used, and explicit, where strategies such as chunking, rehearsal and meta-cognitive strategies are consciously used as strategies to handle the tasks involved (Klingberg, 2010). The effect of training on a particular cortical region, using a specific task would be expected to transfer to other tasks, only to the extent that the tasks rely on the same neural
networks. (Olesen et al, 2004). Only training affecting higher association cortices, might have more general effects.

2.8 THE BRAIN FUNCTIONS THERAPY: The computer based programme used in this study, the Brain Functions Therapy (BFT) was originally used as a technique to enhance core neuropsychological concepts. It has been used both in children as well as adults (Mukundan, 2003) in clinical practice.

In a hospital based study, (Shailaja 2001, Shailaja, Rajah & Mukundan, 2009) used the BFT in a group of adults with traumatic brain injury. 9 adult males, with mild to moderate head injury were selected from a government hospital. They were trained over 30 continuous sessions on the various tasks of the BFT. Pre and post assessment tools included selected tests from the NIMHANS battery of neuropsychological tasks and Rivermead Behaviour Scale. EEG measures were also used. There was clinical improvement in symptoms, measured both by NIMHANS battery, EEG as well as behavioural indices, following the one month training programme. Some of the improvements were statistically significant.

Research using this programme has been limited; however, it has several advantages. It is a simple set of tasks that can be used for adults as well as children. The tasks do not depend upon language skills and hence, can be used for clients with different levels of education. It is reasonably priced, with the system requirements that are not complex. Most important of all, it has been developed with the Indian clientele in mind, for conditions that suit regional needs. This programme was therefore selected as the intervention tool for this research study.

2.9 SUMMARY AND APPRAISAL OF AVAILABLE WORK: Summarizing these findings, the following conclusions emerge:

1. The brain is linked to learning and school performance. Atypical brain development may cause deficits in neuropsychological functions, resulting in academic difficulties.
2. A child with learning difficulties need not have learning disability. The lack of clarity in defining learning difficulty may lead to under-diagnosis of the problem in children and therefore, denial of possible help.

3. Scholastic problems can present as or be associated with emotional or behaviour problems. Scholastic difficulties could well be the starting point for intervention.

4. Identifying children at risk and providing general intervention could be a model for prevention adopted in the Indian context.

Work on intervention, especially for children at risk is an emerging area of research. With increasing availability, computer based interventions have scope for greater use. Cogmed (for working memory) and FastForWord (for phonological processing) are 2 computer based programmes that have been repeatedly used with promising results. Much of the work done has been in children with identified problems in attention, working memory or scholastic difficulties.

Despite small group sizes most studies have included controls, and tried to find out the persistence of gains on 3-6 months follow up. Training has been approximately for 20 sessions, but age range of children has been wide, from preschoolers, 7-12 year olds and adults. Most studies have offered other inducements to children in the form of tokens, games, gifts. In addition, teams of professionals have been involved in training or assessments.

In India, there is a vast and untapped need for mental health services to children. With constraints of time, space, professional expertise and finance, intervention research in child mental health has been few and far between.

Scholastic problems in children are often identified by teachers, but rarely attended to because of the lack of availability of trained personnel. There is little awareness regarding children at risk for scholastic problems. A child in need and left unattended to is a potential source of future problems.

Computer-based training has scope in such a scene. Apart from its availability (in schools) uniformity and controlled delivery, it offers an active outlet for the child to
interact and learn. Possibly, the biggest advantage would be its potential for use in groups, with judicious involvement of professional expertise.

The BFT is an indigenously developed programme that has vast scope for use in children who are at risk for learning problems. The tasks involved are general, primarily visuo-spatial in nature with a great degree of flexibility in presentation, all of which are advantages in using it as a tool for scientific research. This study would therefore address a long-felt need in a developing population. The results of this research would help plan simple yet effective prevention strategies for young children with problems in learning at school.

**Rationale for the study:** This study is an exploratory attempt to understand the profile of children with average scholastic performance in the lower grades and to find out whether a general computer based cognitive intervention would help improve their cognitive, social and academic functioning. The results of this study would help identify children at risk and offer school based interventions that are cost-effective. Secondary prevention measures and community based interventions are neglected areas in child mental health and it is hoped that this study would help plan more such initiatives that would ultimately benefit the child in need.